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AUTHOR	Sachdeva, Darshan
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ABSTRACT

The sign test is perhaps the simplest nonparametric procedure comparable to the commonly used parametric t-test. This test is easily applied which makes it useful preliminary analysis and for the analysis of data of passing interest. A large variety of its applications to education research, usually not found in the standard textbooks, is included in this presentation. In addition, the computing work is kept at an absolute minimum and a minimal use has been made of tables for significance testing. (Author)

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Survey of Some Useful Applications of Sign Test in Educational Research*

Darshan Sachdeva

University of California

Sign test is the simplest nonparametric test procedure comparable to the commonly used parametric t-test. Todhunter (1865) refers to its earliest known use in simple form by Arbuthnot but the modern interest in its application stems from the work of Cochran (1937). At the present time, description of this test procedure is found in a large number of textbooks concerned with the statistical analysis of data but most of these presentations are limited and do not provide extensive applications of this extremely simple test procedure. In addition, when this test is described in the textbooks, however, tables are usually referred to which are really not necessary. In the present narration, applications of Sign test to a variety of educational problems is presented. In addition, a formula based on sample size only has been provided for significance testing as explained below for the case of one sample location problem.

Let $X_1, X_2, \ldots, X_n$ represent a random sample of observations drawn from a continuous population whose median is designed by θ. Since the median is the 50th percentile, one would expect that $P(X_i - \theta > 0) = P(X_i - \theta < 0) = 1/2$. Thus, the hypothesis to be tested is that $P(X_i - \theta > 0) = 1/2$ against the alternative hypothesis $P(X_i - \theta > 0) \neq 1/2$. Let s represent the number of observations that are larger than θ and f be the observations which are smaller than θ. Clearly, s has a binomial distribution. An approximation to this distribution is provided by the normal curve. The closeness of this approximation depends on sample size. Conover (1971) suggests the use of normal approximation for $n > 20$ whereas McNemar (1969) recommends the normal curve approximation to the binomial for $n > 10$. By using normal approximation at $\alpha = 0.05$ level of significance, it is seen that $s = (1/2)\, n \pm 2\sqrt{n/4}$. It can also be seen that $f = (1/2)\, n \pm 2\sqrt{n/4}$. Then at $\alpha = 0.05$ level of significance one can show that $(s - f)^2 = 4n$. Thus, the null hypothesis that the probabilities of plus and minus sign are equal is rejected if $(s - f)^2 \geq 4n$. The application of this formula

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for significance testing has been presented in the following numerical examples.

Example 1. Is there reason to believe that a set of scores, 130, 120, 110, 90, 120, 80, 130, 120, 110, 110, 120, 130, 110, 140, 90, 110, 110, came from a population with average equal to 100. In this case, $n = 17$, $s = 14$, $f = 3$, $(s - f)^2 = (14 - 3)^2 = 121$ which is larger than $4n = 4 \times 17 = 68$ and therefore it is unlikely that the above set of scores came from the population which has an average of 100.

Example 2. A group of remedial readers tested before and after a special instructional program using the same standardized instrument obtained the following scores:

Student #	Before(B)	After(A)	Student #	Before(B)	After(A)
1	138	135	7	203	197
2	195	210	8	120	123
3	164	171	9	181	185
4	158	163	10	144	145
5	133	149	11	152	164
6	208	227			

In this example, $n = 11$, the plus signs of the differences (A - B) are $s = 9$, and also the minus signs of the differences are $f = 2$ with $(s - f)^2 = (9 - 2)^2 = 49$ which is greater than $4n = 4 \times 11 = 44$. Therefore the null hypothesis of no effect of the special instructional program is rejected and it is concluded that the program did have effect.

Example 3. Does the following set of scores exhibit any trend in location: 80, 79, 63, 75, 61, 54, 71, 90, 51, 55, 85, 93, 43, 56, 77, 72, 41, 50, 60, 57, 76, 53, 49, 56, 53, 45, 53. The test involves pairing the latter scores with the earlier numbers and discarding the scores in the middle of the sequence and then applying Sign test to the pairs as shown below

A:	80	79	63	75	61	54	71	90	51
B:	69	57	76	53	49	58	53	45	53
A - B:	+	+	-	+	+	-	+	+	-

This means, $n = 9$, $s = 6$, $f = 3$, $(s - f)^2 = (6 - 3)^2 = 9$ which is smaller than $4n = 4 \times 9 = 36$, therefore there is no evidence of trend in the scores of this sequence.

Example 4. Are the following sets of scores correlated:

X: 31 14 38 28 27 35 24 26 37 19 33 35 20 29 39 24

Y: 72 42 89 60 53 68 77 55 81 37 74 84 46 57 90 66

The procedure involves rearranging, say, Y scores from the smallest to the largest keeping the X scores in the same pair and then applying Sign test to X scores, that is,

X: 19 14 20 27 26 29 28 24 35 31 33 24 37 35 38 39

Y: 37 42 46 53 55 57 60 66 68 72 74 77 81 84 89 90

Now pairing the last eight X scores with the first eight X scores, that is,

Last eight X scores	:	35	31	33	24	37	35	38	39
1st. eight X scores	:	19	14	20	27	26	29	28	24
Sign of the difference:		+	+	+	-	+	+	+	+

Since $n = 8$, $s = 7$, $f = 1$, $(s - f)^2 = (7 - 1)^2 = 36$ which is larger than $4n = 4 \times 8 = 32$. Therefore the null hypothesis of independence is rejected and it is concluded that the X and Y scores are correlated. In fact the product moment correlation coefficient is .86.

In addition to the examples presented here, Sign test can be applied to a variety of other situations. When data are easily gathered, the extraordinary simplicity of the computation involved in carrying out Sign test justifies its application by taking large sample. Furthermore, a simple formula based on sample size only makes its use for significance testing easy and independent of extensive tables. In conclusion, some useful applications of Sign test in educational research for preliminary analysis of data and for the analysis of data of passing interest have been surveyed in this paper. These analyses should be followed by the more appropriate statistical tests as soon as possible.

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